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Fish in the Forest

Large Woody Debris in Streams
A New Management Approach to Fish Habitat

Pools are formed as the stream scours and fills in around the debris.

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Issued in furtherance of USDA Forest Service work
in cooperation with the National Marine Fisheries Service
and Alaska Department of Fish and Game.

Introduction

Habitat Needs of Salmon, Trout, and Char

All five species of Pacific salmon (chinook, coho, sockeye, pink, and chum), steelhead and cutthroat trout, and Dolly Varden char[1/] occur in the freshwater streams of southeast Alaska. These fish, which belong to the salmonid family, generally require two types of freshwater habitat: (1) spawning habitat, where eggs are deposited and incubated, and (2) rearing habitat, where young fish live before migrating to the sea. Pink salmon and chum salmon are the exceptions; these species spawn in streams but their fry move to the ocean soon after hatching. Coho, chinook (king), and sockeye salmon, the trouts, and Dolly Varden char live in the stream for one or more years before migrating to the sea; the quantity and quality of rearing habitat available greatly affect their survival.

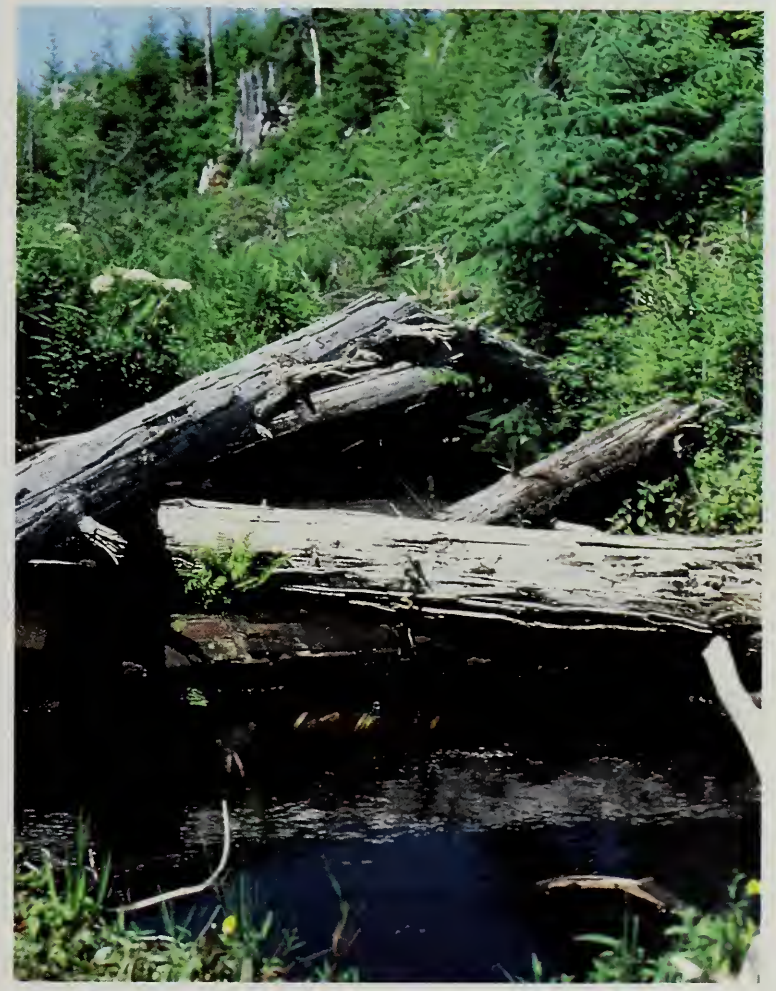
Anadromous Fish

All of these species are anadromous; that is, they migrate between fresh and salt water. Many also migrate extensively within a stream system in response to the demands of different life history phases. The type of habitat suitable for winter use, for example, may be different from that used in summer. Because different types of habitat may be widely separated within a stream system, fish must have routes of access among habitats. Along with main stream channels, seasonally flooded side channels and flood plains provide access and are essential features of productive stream systems.

[1/] Scientific names are given inside back cover.

Left
Spawning habitat, created as a result of large woody debris, offers a place for fish to deposit and incubate eggs.

Right
Rearing habitat for young fish is required before they migrate to sea.



The Role of Large Woody Debris

Many people believe streams should be free from debris, crystal clear, and bubbling over gravel and boulders. To the casual observer, a stream covered with stacks of crisscrossed logs appears to be unnatural and undesirable. Fallen trees and other large pieces of wood do, however, significantly shape the stream channel, provide an energy base (nutrients), and influence the composition of fish species and quantity of fish. Fish need woody debris; it is as much a natural part of their stream habitats as are boulders and water.

Natural Sources of Debris

A stream is strongly influenced by the land surrounding it. In old-growth forests, trees and parts of trees (branches, needles, roots) help shape stream channels and provide cover and food for young and resident fish. Woody material entering the stream is used by a variety of organisms, either directly—as a source of food or cover—or indirectly—by taking advantage of the stream features created by the debris.

Under natural conditions, woody debris can enter a stream suddenly, through blowdown, bank erosion, and landslides, or slowly, from small branches and leaves dropping in autumn. In an old-growth forest, material in streams that gradually decomposes or washes out is constantly replaced. This continual supply of debris maintains the stream habitat that is needed by fish and other organisms.

Left
Woody debris sometimes enters a stream naturally through blowdown.

Right
Branches and leaves dropping in autumn provide a continual supply of debris.

Human Activities as a Source of Debris

Human activities also may cause woody debris to enter streams. Trees may fall into the stream during logging or blow down when narrow strips of timber left along streams during clearcutting are exposed to wind. Large amounts of slash can enter the stream during and after logging, and road construction activities also may result in trees entering streams.

Natural Debris vs. Logging Debris

Natural processes and human activities result in different types of debris accumulations. In general, naturally occurring material is larger and there are more trees and attached roots rather than individual branches. Natural accumulations are less dense and are usually distributed in patches throughout the course of the stream. Logging debris contains more slash and bark than does natural debris. Root wads may be common in logging debris but are usually cut at the base and detached from the bole. Dense accumulations of slash are common in those portions of the stream that are within clearcuttings. Logging debris usually enters the stream in a single season, whereas naturally occurring materials continuously accumulate and dissipate. Logging debris and logging-related blowdown usually consist of green wood; natural debris may be partially decomposed when it enters the stream.

The differences between the two types of debris affect the behavior of the debris in the stream. In both natural and logged areas, when woody debris enters the stream, bank cutting and scour occur as water flows around the debris and moves it into a stable position. Bank cutting may undercut root systems of streamside trees, which causes those trees to fall into the stream. Additional trees falling into the stream continue the cycle.

Opposite page
Old logging-related debris or debris caused by other human activities may enter streams.

For streams without large streamside trees, this cycle of debris addition and depletion is broken. Except for slash and other debris that result from timber harvest, no new debris will enter the stream until regeneration of the surrounding forest again provides trees. Because logging debris is smaller and more densely concentrated, it is less stable when it enters the stream and will remain unstable over a longer period of time. Furthermore, such debris may destabilize existing accumulations of natural debris and cause them to shift downstream. The long-term effect of clearcutting streamside areas is, therefore, to severely diminish the natural input of tree-size debris into the stream.

Left
Natural accumulations are less dense and distributed in patches along the course of the stream.

Right
New logging debris is often smaller with more dense accumulations and enters the stream in a single season.

Effects of Woody Debris in Streams

Changing Stream Channels Create New Habitat

The primary effects of logs and trees on stream channels are related to changes in streamflow patterns. Pools are formed by the stream scouring around and under logs. Gravel and sediment are stored behind logs and debris jams. Undercut banks are created by water being deflected against a stable bank. All of these features contribute to a variety of habitat types that can be used by salmonids and the organisms they feed on.

The effects of debris on stream channels are largely functions of the size of the debris and the size of the stream. Woody debris has more influence on habitat development in small streams than in large streams, in part because relatively more stream area is affected in a smaller stream. Large debris may change the course of smaller streams, whereas the most important habitat changes in larger streams are usually along the edges.

Debris affects the shape of stream channels by controlling stream flow and sediment movement. A single tree in the stream channel may deflect water flow against the opposite bank, which results in scouring and undercutting of the bank. Additional scour under and around the tree will create a small pool in front of it. An accumulation of several trees may create a complex system of pools and side channels in and around the accumulation. Under these conditions, the stream scours and fills around the debris to create pools, side channels, and undercut banks.

Shape and stability of the channel is affected by debris which controls the shape of the stream, scouring and filling in around the debris.

New Habitat

Logs or trees that extend across the channel may form dams or scour pools. In many cases, these dams can retain significant amounts of gravel suitable for spawning, or they can trap fine organic material that can be used by aquatic insects and other stream invertebrates. Pools below the dams provide living space for fish. Trees with attached root wads form complex habitats along the edges of larger streams. In low-gradient terrain, trees and root wads may partially deflect flows into side channels that can provide highly productive habitat for young fish.

The physical effects on the stream channel can occur either from natural debris accumulations or from debris associated with human activity. Natural debris is more desirable than logging debris because of the presence of attached root wads. Because logging debris tends to be unstable and to contain large amounts of fine material, it may increase sedimentation, cause excessive scouring of spawning gravels, and increase biological oxygen demand (thereby reducing the amount of dissolved oxygen) for several years following logging. Only after large woody debris stabilizes and is incorporated into the stream system will it contribute to the formation of pools and overhead cover.

Larger pieces of debris, such as logs, stabilize rapidly. Logs form pools, act as deflectors, and may line stream banks. Banks in such areas may be gradually undercut, thereby providing important overhead cover. Root wads also create undercut banks and pools that have complex cover among the roots.

Debris Influences Habitat For Young Fish

Woody debris has a direct influence on the size and structure (species and age composition) of fish populations in streams. The number of coho salmon, trout, and Dolly Varden is directly related to the amount of instream large woody debris. In general, the more large woody debris a stream system contains, the more fish are found. Figure 1 shows this relationship for juvenile coho salmon in winter.

Woody debris accumulations are natural features of forest streams and have influenced the evolution and development of fish. The influence of debris may be direct and obvious, as previously described, or it may be indirect. Many young salmon maintain territories that they vigorously defend from competitors. Aggressive behavior by one fish is initiated by the sight of another fish in its territory. Logs and branches block the vision of adjacent fish and effectively divide the available habitat into smaller units or territories. This allows more fish to occupy a given area of stream. Woody debris also provides important cover for protection of young fish from predators, such as larger fish, birds, and mammals.

Large debris in streams can provide protection from high water velocities and turbulence during autumn and winter floods. Eddies and backwaters created by large debris provide refuge areas for young fish in an otherwise hostile environment. Gravel moved during freshets can crush eggs and fry in unstable stream channels or displace fish to salt water where they will probably die.

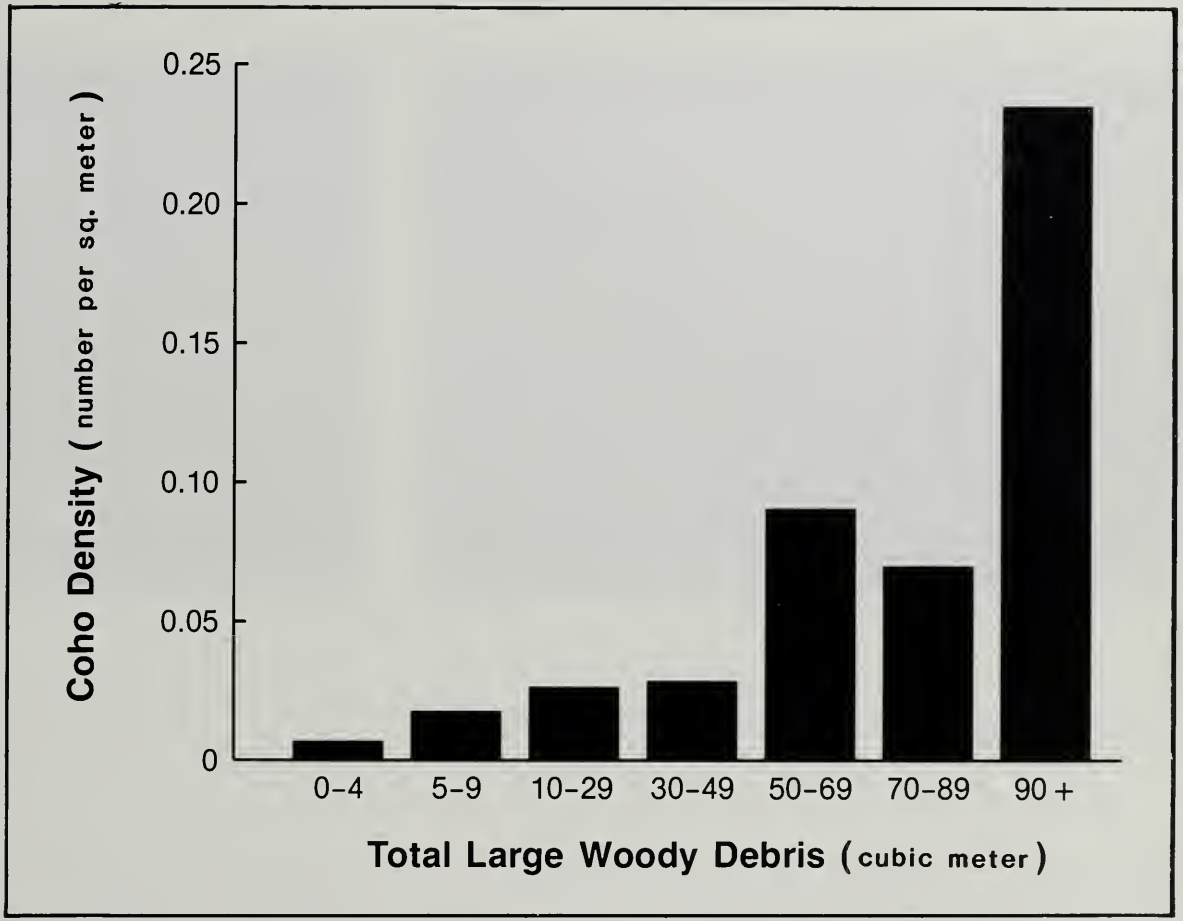


Figure 1— **Relation between volume of large woody debris and density of coho salmon in winter.**

Left
Dams or scour pools may be formed by logs or trees extending across the channel.

Right
Root wad and stem form midchannel pools.

Spawning Habitat and Migration Influenced by Woody Debris

Woody debris has a different function for spawning adult salmon than for young fish. Large accumulations of woody debris do not necessarily improve spawning habitat. Successful spawning of pink and chum salmon depends, among other factors, on large, stable gravel beds. Debris accumulations can be either beneficial or detrimental to spawning salmon, depending on the size of the material, how it is incorporated into the stream, and the degree of concentration. Although woody debris in spawning areas is needed for cover and stream channel stability, excessive amounts can cause changes in the channel that may increase water velocities above levels appropriate for spawning. Debris jams can cause the accumulation of fine sediment and organic material in spawning gravels, thereby reducing oxygen content. In some instances where debris is heavily concentrated, migration of adults can be impeded or delayed until high water provides access over or through the debris jam.

Tree-sized material can sometimes stabilize spawning gravel. It can also form large pools that provide cover and rest areas for adult salmon moving upstream to spawn. During dry periods, spawners seek out deep pools formed by logs and other debris. During floods, adults are often found in debris-formed pools or behind other obstructions where the water velocity is minimal. This is especially true of adult coho salmon that must contend with heavy floods during autumn and early winter. In small to medium-sized streams where high velocity would otherwise impede the migration of adults, fallen trees can form a series of "channel-stepping" pools that act as a natural fish ladder and provide access to upstream waters. During the driest months, usually July and early August, water depth in spawning riffles can be so shallow as to prevent upstream migration and expose adults to predation. Though removal of large debris from riffles can increase the amount of available spawning area, such removal may have an overall negative effect by destabilizing the stream channel and reducing the variety of habitat within the stream.

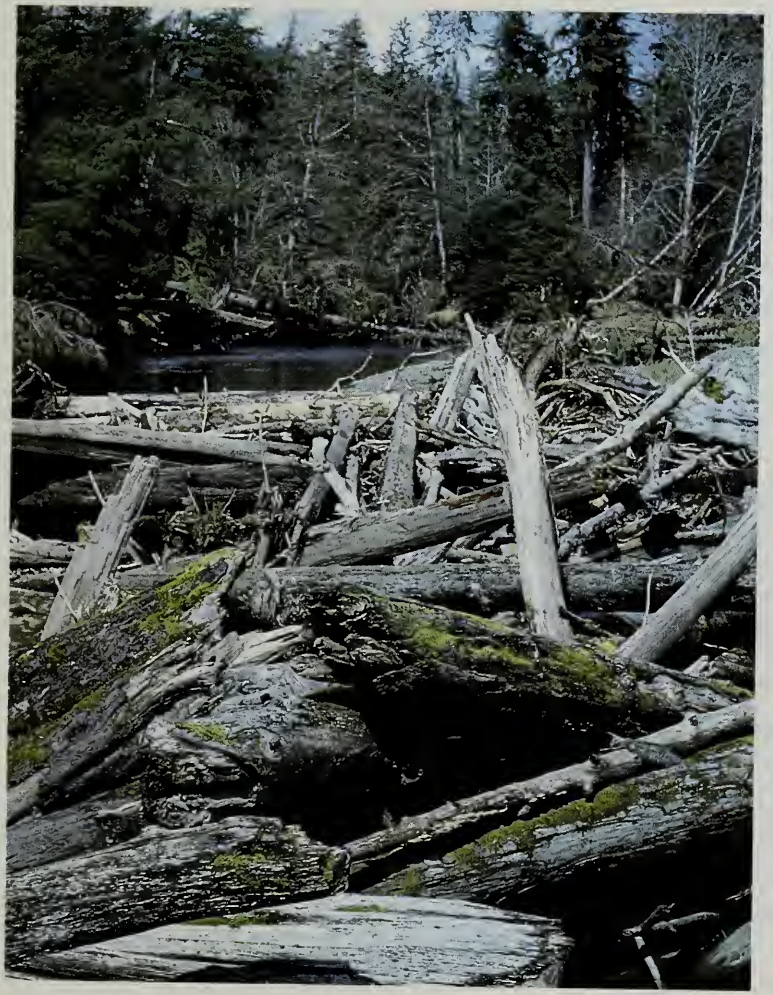
Opposite page:

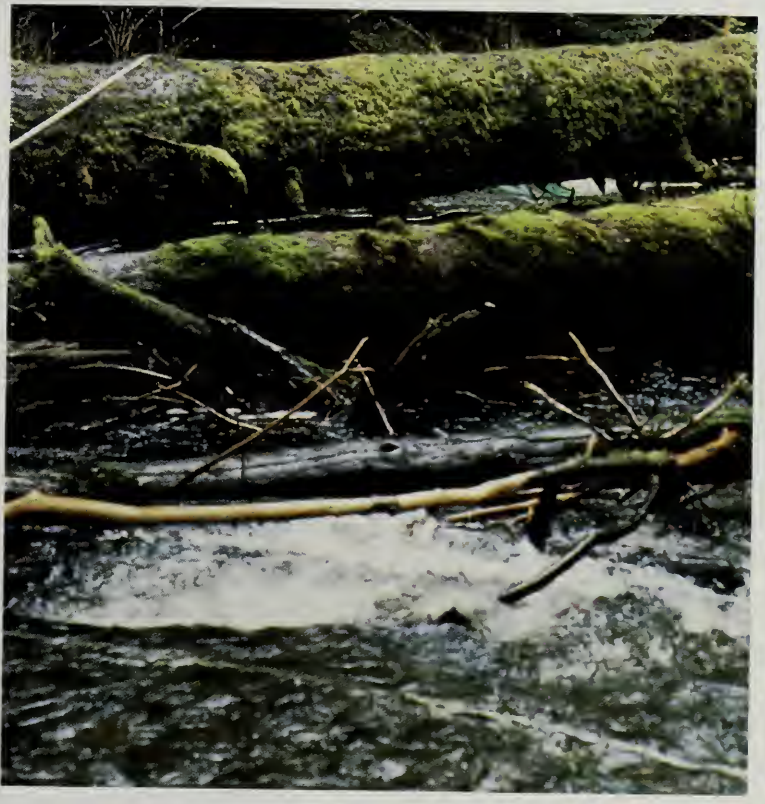
Left

Large, well-established debris jam may delay fish migration.

Right

Pools, rearing habitat for young fish, are formed by debris in high-velocity streams.





Managing Woody Debris

Recognition of the importance of woody debris places new responsibilities on those agencies that manage streams and fish habitat. Debris management is complex; it is not a matter of simply placing woody material into debris-poor streams or of limiting the addition of logging slash. For many years, all debris was considered detrimental to fish and was removed from streams in logged watersheds. Blowdown was also considered to be "wasted timber," if not quickly removed from the stream and salvaged. Although some debris removal may have been beneficial, most of it probably resulted in reduced fish production. New information on the relation between woody debris and fish populations is rapidly accumulating and leading to new policies of stream management. The objectives of management are to:

Objectives

- Maintain streambank and channel stability.
- Maintain or enhance habitat for resident and young fish.
- Provide access for adult salmon to upstream spawning areas while providing holding pools and protective cover.
- Maintain a variety of habitat types—pools and riffles—throughout the course of the stream.
- Provide for sport fishing activities.

Opposite page

Selective harvesting of streamside timber still provides habitat protection.

Potential ways to manage streamside areas to insure that debris will continue to enter the stream are to:

Methods

- Leave a fringe of undisturbed streamside trees.
- Selectively harvest trees within the streamside area.
- Harvest timber in patches along streams. Some openings in the canopy will provide increased sunlight for greater production of stream organisms that form the base of the fish's food chain. At the same time, sufficient mature trees and other vegetation will be retained to provide a continuing supply of woody debris along the entire stream.

Summary

Large woody debris is an important component of the stream habitat of salmon, trout, and char. It can be either beneficial or detrimental.

Benefits

- Provides cover for fish
- Provides protection for spawning adults from predators
- Creates pools
- Increases habitat diversity for fish and aquatic insects
- Aids fish migration during periods of low water
- Improves access in high-velocity stream sections by creating "channel-stepping" pools
- Traps gravel that can be used for spawning habitat
- Traps sediments and slowly releases it downstream
- Creates diverse stream velocity patterns
- Forms a nutrient base for stream organisms that eventually become fish food
- Deflects streamflow, which creates undercut banks and channel diversity
- Stabilizes streambanks

Although woody debris accumulations can have detrimental effects, these are generally temporary and are far outweighed by beneficial aspects. Debris management is not a simple task: it is neither a case of removing all debris nor of adding it indiscriminately. A continuous source of woody debris should be provided to the stream environment, through a controlled management program.

Glossary[2]

Common name	Scientific name
Chinook salmon	*Oncorhynchus tshawytscha* (Walbaum)
Coho salmon	*Oncorhynchus kisutch* (Walbaum)
Sockeye salmon	*Oncorhynchus nerka* (Walbaum)
Pink salmon	*Oncorhynchus gorbuscha* (Walbaum)
Chum salmon	*Oncorhynchus keta* (Walbaum)
Rainbow (steelhead) trout	*Oncorhynchus mykiss* [3]
Cutthroat trout	*Oncorhynchus clarki* [3]
Dolly Varden char	*Salvelinus malma* (Walbaum)

[2] From "A List of Common and Scientific Names of Fishes from the United States and Canada," American Fisheries Society Special Publication No. 6, 3d edition, 1970, 150 p.

[3] From Smith, Gerald R., and Ralph F. Stearley, "The Classification and Scientific Names of Rainbow and Cutthroat Trouts" in Fisheries Vol. 14, No. 1.

Further Informati

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